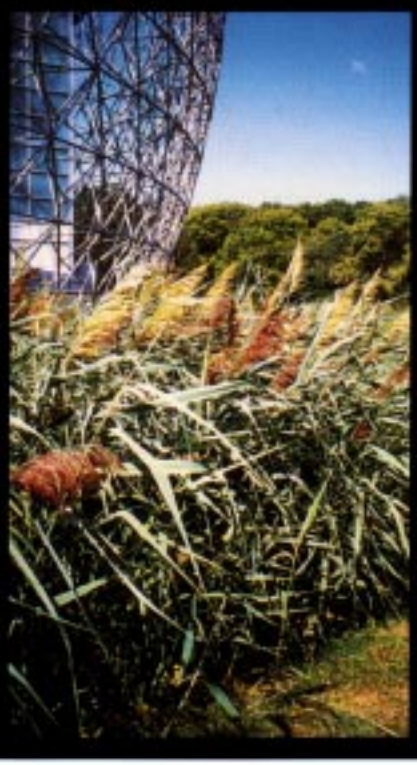
St. Lawrence TECHNOLOGIES

ABSTRACT

Extended wastewater treatment plants employ artificial ecosystems of varying shapes and designs on relatively large terrains to treat effluents. The pilot plant at the Biosphere, an ecowatch centre in the former United States pavilion of Expo 67, is composed of a mosaic of plant communities and operates without benefit of mechanical equipment or major energy support. This technology is a simple, economical and effective way to treat the wastewater of small communities in temperate climes, and proved very adaptive to our climate. The project included overseeing the design and construction of a pilot plant and monitoring treatment efficiency.

INDUSTRIAL WASTEWATER

AN EXTENDED WASTEWATER TREATMENT SYSTEM



HIGHLIGHTS

- **Technology**
  - Based on the filtering properties of aquatic plants.
  - Plant comprised of six ecosystems arranged in such a way to optimize treatment.
  - Minimal residence time of ten days; flow rate of about 15 m^3/d.
  - Total treatment surface area of 800 m^2.

- **Environment**
  - Treatment plant that blends into the surrounding urban park and the Biosphere.
  - Odourless.
  - During the first five months of operation, a reduction rate of greater than 80% was generally achieved and treated wastewater conforms to standards currently in effect, except at start-up.
  - SS, BOD_5, COD and phosphorus capture is achieved primarily in the reed-grass beds.

Saint-Laurent Vision 2000

Environment Canada Protection Québec Region
Environnement Canada Protection Région du Québec

Institut de recherche en biologie végétale

Le Groupe Steica Inc.

SODINCO INC.

soprin Experts-conseils

PROJECT OBJECTIVES

The aim of the project was to design, build and monitor an economical wastewater treatment plant that is adapted to the needs of the Biosphere, an environmental museum located in an urban park with tremendous tourist potential.

Existing extended filtering treatment plants vary greatly in terms of design. This project took a European design and adapted it to the Quebec context. The particularities of our climate, plant species best suited to the treatment of wastewater and the characteristics inherent to this water were all taken into consideration. Project constraints included the need to fully integrate the plant into the surrounding urban park, to eliminate all odours, especially those from the initial start-up of the treatment process, and to design a system that could support an unusually large flow variation, given that the Biosphere could receive up to 6000 visitors per day.

The research component was also an important part of this project: it is hoped that the knowledge gained by monitoring the process — from June 1995 to December 1997 — will optimize its operation, clearly establish the potential for use of this technology in similar environments, and draft design criteria for such systems in southern Quebec.

BACKGROUND

Conventional treatment plants are very well adapted to the needs of medium or large cities. In smaller towns, however, these technologies are sometimes inefficient or too costly relative to their needs and paying capacity.

Extended wastewater treatment systems, on the other hand, offer a number of qualities that make them a suitable solution for small towns. They are as follows:

- Low construction and operating costs.
- Efficient and reliable, with a treatment rate similar to tertiary treatment systems.
- Able to disinfect treated water.
- Easy to maintain in operation.
- Frequent source of indirect benefits, such as its capacity to blend into natural and urban green spaces.

The European experience shows that extended filtering systems are very effective where the appropriate design criteria and plant species selection have been established. The technology being used at the Biosphere is available in Germany, Belgium and Denmark, where it has proven its efficiency. However, taking into account the differences between the climatic conditions, plant species and wastewater characteristics of southern Quebec and these countries, a thorough evaluation of the performance capacity of the Biosphere's system was necessary to ensure its optimal operation.

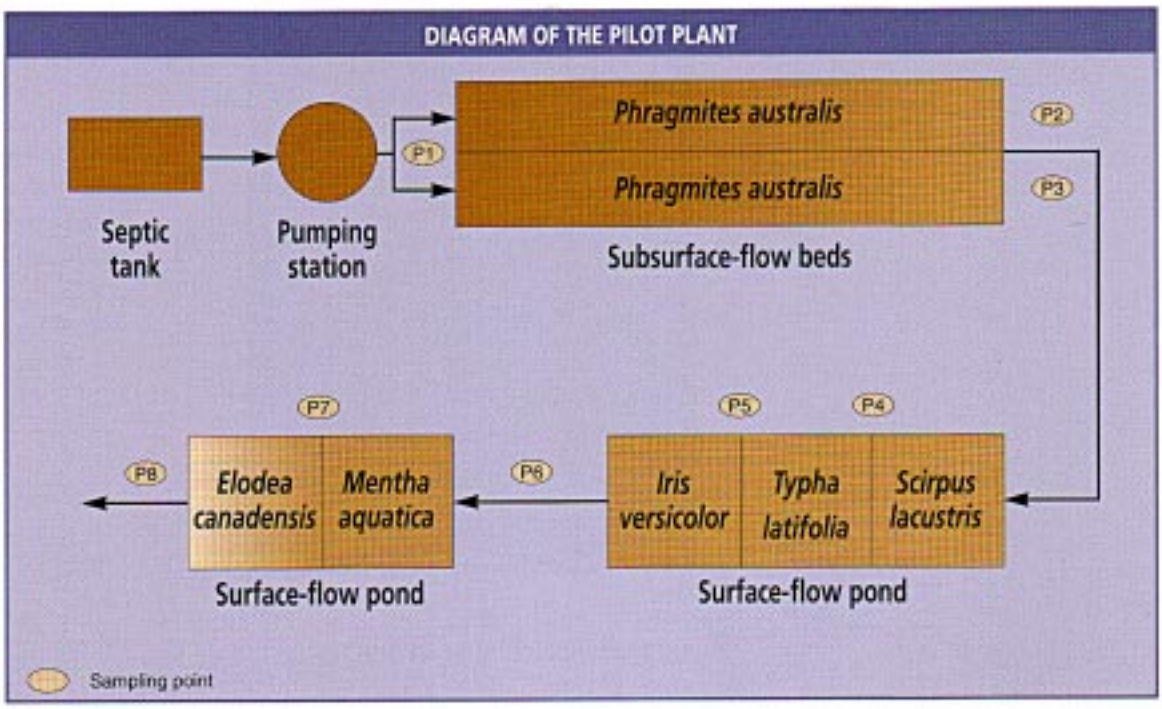
TECHNOLOGY

The chosen design is a mosaic of artificial plant communities. A total of six ecosystems were selected, with each being arranged in terms of its specific filtering characteristics so as to optimize the overall efficiency of the system.

Given that the site selected for the plant is a public recreation area, initial flow rates were established based on anticipated traffic and regional weather patterns.

The system includes:

- A septic tank, a pumping station and a distribution chamber.
- A first treatment module made up of two parallel subsurface-flow beds colonized by Common reed-grass (*Phragmites australis*) and



RESULTS

fed by a pressurized longitudinal pipe.

- A second treatment module made up of two successive surface-flow ponds containing semi-aquatic and aquatic plant species. The first pond, containing a sequence of Marsh bulrush (*Scirpus lacustris*), Broad-leaved cat-tail (*Typha latifolia*) and Blueflag (*Iris versicolor*), finalizes treatment. The second pond, occupied by a community of Water mint (*Mentha aquatica*) followed by a community of Canada waterweed (*Elodea canadensis*) serves to disinfect and oxygenate the water.

The pilot plant has been monitored since its opening on June 5, 1995; results presented here are for June 12 to November 13, 1995. Sampling was done every two weeks; a composite sample was formed of subsamples drawn every hour at each sampling point, in order to measure SS, COD, TKN, NH_4^+. Grab samples were also drawn to check for BOD_5, phosphorus (PO_4^{-2} and P_{tot}), and bacteria (fecal coliforms, total coliforms, fecal streptococci, total bacteria at 22°C and 35°C). The following parameters were also measured in the field: dissolved oxygen, temperature, conductivity and pH. Above-ground plant biomass was evaluated in October 1995.

Treatment efficiency rates were excellent during this first year of operation. Outflow effluent only rarely exceeded discharge standards for this type of effluent (Regulation 87 of the Montreal Urban Community); indeed, most of the time the two reed-grass beds alone were sufficient in this regard. SS, BOD_5, COD and phosphorus capture are achieved primarily in these two beds, with successive ponds playing only a minor role in the filtering process.

Nitrogen (TKN and NH_4^+) removal occurs gradually all along the treatment sequence; levels generally increased during the summer. Dissolved oxygen was never considered a limiting factor in this first year of operation, and pH was always within acceptable limits. Detailed results are shown in Table 1.

Growth rates were good for Common reed-grass, Marsh bulrush and Broad-leaved cat-tail, but not for Blueflag, Water mint and Canada waterweed. This failure to thrive appears to be related to an inability to adapt to this environment. The productivity of species with normal plant growth was slightly lower (reed-grass) or much lower (Marsh bulrush and Broad-leaved cat-tail) than for these same species under similar conditions. Nonetheless, this situation is normal since these young ecosystems are experiencing their first year of growth in these ponds.

TABLE 1 RESULTS FOR JUNE 12 TO NOVEMBER 13, 1995 AT THE OUTLET OF THE PILOT PLANT

Substance	MUC standard*	Mean concentration	Minimum concentration	Maximum concentration	Treatment rate (%)
SS (mg/L)	30	20.0	4	60**	67.8
BOD_5 (mg/L)	30	3.8	1	10	97.1
COD (mg/L)		40.4	19	62	85.6
TKN (mg/L)		9.6	2.0	20	81.6
NH_4^+ (mg/L)		7.4	0.2	19.6	84.7
Total P (mg/L)	1	0.16	0.02	1.32**	97.7
PO_4^{-2} (mg/L)		0.02	0.01	0.08	99.6
Fecal coliforms (log unit/100 mL)	2.6	2.2	0	2.9**	99.96
Total coliforms (log unit/100 mL)	3.4	2.5	0	3.2	99.99
Total heterotrophic bacteria (22°C) (log unit/100 mL)		5.6	4.0	6.3	99.92
Total heterotrophic bacteria (35°C) (log unit/100 mL)		5.6	5.1	6.2	99.92
Fecal streptococci (log unit/100 mL)		1.8	0	2.6	99.74
Dissolved oxygen (mg/L)		8.9	6	18.5	
Conductivity (mS/m)		49.4	25	72	
pH	between 6.0 and 9.5		7.37	8.01	
Temperature (°C)	65	19.6	7.7	25.7	

* Standards of the Regulation Relative to Wastewater Discharges to Sewers And Waterways (Regulation 87 of the Montreal Urban Community).
** A single exceedance of standards was reported for this substance; it occurred at start-up of the pilot plant.

POTENTIAL AND LIMITATIONS

Given that this treatment plant is still in a period of adjustment, the results obtained during its first year of operation do not necessarily represent future results. In fact, the plants have not reached their full size or their maximum density and some species have had problems adjusting to the ponds. Adjustments have been made in 1996, and we will only be able to determine accurately the treatment rates of this pilot plant at the end of 1996.

Regardless, the treatment efficiency rates throughout this first year of operation were excellent. The reed-grass beds alone appear to be able to attain the discharge objectives of most of the substances measured.

Given these results, it may be possible to increase influent wastewater flows over the next few years. This possibility will be carefully evaluated throughout the monitoring process.

INFORMATION

This technology data sheet is based on the results of a technology development project carried out by the Institut de recherche en biologie végétale, in cooperation with the Fondation universitaire luxembourgeoise, Groupe Steica Inc., Groupe Sodinco Inc., Soprin Experts-conseils Inc., the ministère de l'Environnement et de la Faune du Québec, the Centre québécois de valorisation des biomasses et des biotechnologies, the Biosphere, Environment Canada, and the Federal Office of Regional Development (Quebec).

For additional information, contact:

Lucie Olivier, MSc.
Environment Canada
Environmental Protection Branch
105 McGill Street, 4th Floor
Montreal, Quebec
H2Y 2E7
Tel.: (514) 283-9274
Fax: (514) 496-2901

Gilles Vincent, MSc.
City of Montreal
City Hall
Mayor's Office
275 Notre-Dame Street E.
Montreal, Quebec
H2Y 1C6
Tel.: (514) 872-0961
Fax: (514) 872-3124

St. Lawrence TECHNOLOGIES

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Environment Canada
Technology Development Section
105 McGill Street, 4th Floor
Montreal, Quebec
H2Y 2E7
Tel: (514) 283-9274

Production:
Dianne Ouellet
Hélène Perrault

Writers:
Lucie Olivier, MSc.
Gilles Vincent, MSc.

Layout and printing:
J. B. Deschamps Inc.

Editor:
Patricia Potvin

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